WHAT IS CLAIMED IS:

1. A long vertical shaft bio-reactor for the purification of waste waters containing biodegradable organic matter comprising:

at least one primary downflow channel extending downward to a depth of approximately 70-90% of a total depth of the bio-reactor;

at least one primary upflow channel in fluid connection with said primary downflow channel defining a mixing zone located below a lower port of the primary downflow channel, said primary upflow channel partitioned by at least one partition, valve, or baffle into at least first and second superior upflow channels fluidly connected with said primary upflow channel;

said first superior upflow channel in fluid connection with said primary downflow channel through a first head tank, said first head tank fitted with a degassing plate to direct flow from said first superior upflow channel laterally to effectuate degassing;

a waste water influent channel fluidly connected with said first superior upflow channel;

a first fluid flow regulator operable to regulate fluid flow between said waste water influent channel and said first superior upflow channel;

said second superior upflow channel in fluid connection with a second head tank, said second head tank fitted with a degassing plate to direct flow from said second superior upflow channel laterally to effectuate degassing;

a recirculation channel fluidly connected with said second superior upflow channel;

a second fluid flow regulator operable to regulate fluid flow between said recirculation channel and said second superior upflow channel; and,

a gas distribution port for distributing an oxygen-containing gas into said primary upflow channel to generate air-lift within said primary upflow channel.

2. The long vertical shaft bio-reactor of claim 1, wherein said primary upflow channel is partitioned by at least one diversion baffle located and configured to direct a predetermined fraction of said oxygen-containing gas rising in said primary upflow channel into one or more of said superior upflow channels, and to simultaneously divert a different fraction of total fluid flow into one or more of said superior upflow channels.

3. The long vertical shaft bio-reactor of claim 1, wherein a residence time of fluid in said primary upflow channel is adjustably controlled by diverting a predetermined fraction of said oxygen-containing gas rising in said primary upflow channel into one or more of said superior upflow channels, and simultaneously diverting a different fraction of total fluid flow into one or more of said superior upflow channels.

4. The long vertical shaft bio-reactor of claim 1, further comprising a recycle channel between said first head tank and said first superior upflow channel to optionally divert recycled, degassed fluid from said first head tank into said first superior upflow channel, wherein a residence time of fluid in said primary upflow channel is adjustably controlled in part by providing a diversion baffle located and configured to direct a predetermined fraction of said oxygen-containing gas rising in said primary upflow channel into one or more of said superior upflow channels, and to simultaneously divert a different fraction of total fluid flow into one or more of said superior upflow channels, and wherein said residence time of fluid in said primary upflow channel is further adjustably controlled in part by selectably adjusting a recycle flow rate between said recycle channel into said first superior upflow channel and or by selectably adjusting a

recirculation flow rate between said recirculation channel and said second superior upflow channel.

5. The long vertical shaft bio-reactor of claim 1, wherein said waste water influent channel is fluidly connected with said first superior upflow channel by a downflow channel connecting to said first superior upflow channel by an upwardly directed port.

6. The long vertical shaft bio-reactor of claim 1, wherein said recirculation channel is fluidly connected with said second superior upflow channel by a downflow channel connecting to said second superior upflow channel by an upwardly directed port.

7. The long vertical shaft bio-reactor of claim 1, wherein said second head tank is fitted with a discharge device to optionally discharge effluent from said second head tank.

8. The long vertical shaft bio-reactor of claim 7, further comprising a clarifier to which said effluent is optionally discharged from said second head tank.

9. The long vertical shaft bio-reactor of claim 1, wherein a residence time of fluid in said primary upflow channel is adjustably controlled to approximately match an oxygen supply rate in said bio-reactor with an oxygen up-take rate by a biomass of microorganisms in said bio-reactor.

10. The long vertical shaft bio-reactor of claim 1, wherein voidage control in the bio-reactor is effectively achieved by regulating an amount of degassed recycle fluid flow between said second head tank and said second superior upflow channel.

11. The long vertical shaft bio-reactor of claim 1, wherein voidage control is effectively achieved by regulating an amount of degassed recycle flow between said second head tank and said second superior upflow channel without altering a flow of oxygen-containing gas into said primary upflow channel.

12. The long vertical shaft bio-reactor of claim 1, wherein a residence time of fluid in said primary upflow channel is adjustably controlled by adjusting voidage through regulating an amount of degassed recycle flow between said second head tank and said second superior upflow channel.

13. The long vertical shaft bio-reactor of claim 1, wherein flow of oxygen-containing gas into one or more of said superior upflow channels is adjustable independent of fluid flow rate into said one or more superior upflow channels,

14. The long vertical shaft bio-reactor of claim 1, wherein flow of oxygen-containing gas into said first superior upflow channel is adjustable independent of fluid flow rate into said first superior upflow channel.

15. The long vertical shaft bio-reactor of claim 1, wherein flow of oxygen-containing gas into said second superior upflow channel is adjustable independent of fluid flow rate into said second superior upflow channel.

16. The long vertical shaft bio-reactor of claim 1, wherein recycling or recirculation of degassed fluid from said first and/or second head tank into said first and/or second superior upflow channel(s) is adjustably controlled by a system microprocessor-controlled or manual-controlled valve or baffle actuator.

17. The long vertical shaft bio-reactor of claim 1, further comprising a sedimentation clarifier.

18. The long vertical shaft bio-reactor of claim 1, further comprising a polishing biofilter.

19. The long vertical shaft bio-reactor of claim 1, further comprising a disenfection chamber.

20. The long vertical shaft bio-reactor of claim 1, further comprising means for returning settled activated sludge into said bioreactor.

21. The long vertical shaft bio-reactor of claim 1, further comprising attachment media for attachment of microorganisms fixed or circulating within said second head tank and/or within said first superior upflow channel.

22. The long vertical shaft bio-reactor of claim 1, further comprising a self-batching air lock interposed between said first and second superior upflow channels.

23. The long vertical shaft bio-reactor of claim 1, further comprising waste solids extraction means for extracting waste solids from a lower portion of the bio-reactor.

24. The long vertical shaft bio-reactor of claim 1, further comprising a shear header or bubble distribution mechanism operably integrated with said gas distribution port to enhance mixing and/or bubble generation in said mixing zone.

25. The long vertical shaft bio-reactor of claim 1, which is selectably operable to provide a substantially anaerobic environment in said primary downflow channel and said first superior upflow channel.

26. The long vertical shaft bio-reactor of claim 1, which can be adjusted to provide a substantially anaerobic environment in said primary downflow channel and said first superior upflow channel, wherein operation of the bio-reactor in this mode provides for a final step of nutrient processing including denitrification of nitrate.

27. The long vertical shaft bio-reactor of claim 1, which is adjustable to provide enhanced nitrification processes in a second treatment zone defined by said second superior upflow channel and said second head tank interconnected by said recirculation channel.

28. The long vertical shaft bio-reactor of claim 27, further comprising fixed or moving attachment media in said second treatment zone to further enhance said nitrification processes.

29. The long vertical shaft bio-reactor of claim 1, which is adjustable to provide enhanced nitrification in a second treatment zone defined by said second superior upflow channel and said second head tank interconnected by said recirculation channel, said nitrification processes driven at least in part by channeling of unspent gas from said primary upflow channel into said second superior upflow channel.

30. The long vertical shaft bio-reactor of claim 1, which features a modular reactor component having a central conduit surrounded by one or more channel-forming radial partition(s).

31. The long vertical shaft bio-reactor of claim 29, wherein said unspent gas is high in carbon dioxide which provides a source of inorganic carbon to drive said nitrification processes.

32. A long vertical shaft bio-reactor for the purification of waste waters containing biodegradable organic matter comprising:

at least one primary downflow channel extending downward to a depth of approximately 70-90% of a total depth of the bio-reactor;

at least one primary upflow channel in fluid connection with said primary downflow channel defining a mixing zone located below a lower port of the primary downflow channel, said primary upflow channel partitioned by at least one partition, valve, or baffle into at least first and second superior upflow channels fluidly connected with said primary upflow channel;

said first superior upflow channel in fluid connection with said primary downflow channel through a first head tank, said first head tank fitted with a degassing plate to direct flow from said first superior upflow channel laterally to effectuate degassing;

a waste water influent channel fluidly connected with said first superior upflow channel;

a first fluid flow regulator operable to regulate fluid flow between said waste water influent channel and said first superior upflow channel;

said second superior upflow channel in fluid connection with a second head tank, said second head tank fitted with a degassing plate to direct flow from said second superior upflow channel laterally to effectuate degassing;

a recirculation channel fluidly connected with said second superior upflow channel;

a second fluid flow regulator operable to regulate fluid flow between said recirculation channel and said second superior upflow channel; and,

a gas distribution port for distributing an oxygen-containing gas into said primary upflow channel to generate air-lift within said primary upflow channel, wherein said first superior upflow channel and said first head tank partially define a first treatment zone and said second superior upflow channel and said second head tank partially define a second treatment zone.

33. The long vertical shaft bio-reactor of claim 32, wherein said first and second treatment zones are structurally segregated to prevent substantial liquid transfer between said first and second treatment zones.

34. The long vertical shaft bio-reactor of claim 32, wherein said first and second treatment zones are structurally segregated by a self-batching air lock that functions to substantially prevent fluid transfer between said first and second treatment zones to minimize heat loss in the bio-reactor.

35. The long vertical shaft bio-reactor of claim 32, wherein said first treatment zone surrounds or is positioned adjacent to said second treatment zone.

36. The long vertical shaft bio-reactor of claim 32, wherein said first treatment zone further comprises said primary downflow channel and said primary upflow channel.

37. The long vertical shaft bio-reactor of claim 32, wherein said second treatment zone is surrounded by a second sealed outer wall to minimize heat loss from the bio-reactor to surrounding geological materials.

38. The long vertical shaft bio-reactor of claim 32, wherein each of said first and second treatment zones comprise independent aeration means.

39. The long vertical shaft bio-reactor of claim 32, wherein each of said first and second treatment zones comprise an upper circulating zone and a lower pseudo plug flow zone.

40. The long vertical shaft bio-reactor of claim 32, wherein deoxygenation in said first treatment zone can be achieved without mechanical mixers.

41. The long vertical shaft bio-reactor of claim 32, wherein denitrification in said first treatment zone can be achieved without mechanical mixers.

42. An improved waste water treatment process utilizing a long vertical shaft bio-reactor comprising simultaneously diverting a predetermined fraction of oxygen-containing gas rising in a primary upflow channel of said bio-reactor into one or more superior upflow channels, and simultaneously diverting a different fraction of total fluid flow into one or more of said superior upflow channels.

43. The improved waste water treatment process of claim 42, wherein a residence time of fluid in said primary upflow channel is adjustably controlled by diverting a predetermined fraction of said oxygen-containing gas rising in said primary upflow channel into one or more of said superior upflow channels, and simultaneously diverting a different fraction of total fluid flow into one or more of said superior upflow channels.

44. The improved waste water treatment process of claim 42, further comprising diverting recycled, degassed fluid from a first head tank into a first superior upflow channel channel of said bio-reactor, wherein a residence time of fluid in said principal upflow channel is adjustably controlled in part by providing a diversion baffle located and configured to direct a predetermined fraction of said oxygen-containing gas rising in said primary upflow channel into one or more of superior upflow channels, and to simultaneously divert a different fraction of total fluid flow into said one or more of superior upflow channels.

45. The improved waste water treatment process of claim 44, wherein said residence time of fluid in said primary upflow channel is further adjustably controlled in part by selectably adjusting a recycle flow rate of degassed fluid into said one or more superior upflow channels.

46. The improved waste water treatment process of claim 42, wherein a residence time of fluid in said primary upflow channel is adjustably controlled to approximately match an oxygen supply rate in said bio-reactor with an oxygen up-take rate by a biomass of microorganisms in said bio-reactor.

47. The improved waste water treatment process of claim 42, wherein voidage control in the bio-reactor is effectively achieved by regulating an amount of degassed recycle fluid flow between a second treatment zone head tank and a second treatment zone superior upflow channel of said bioreactor.

48. The improved waste water treatment process of claim 42, wherein voidage control is effectively achieved by regulating an amount of degassed recycle flow between a second treatment zone head tank and a said treatment zone superior upflow channel without altering a flow of oxygen-containing gas into said primary upflow channel of the bio-reactor.

49. The improved waste water treatment process of claim 42, wherein a residence time of fluid in said primary upflow channel is adjustably controlled by

adjusting voidage through regulating an amount of degassed recycle flow between said second treatment zone head tank and said second treatment zone superior upflow channel.

50. The improved waste water treatment process of claim 42, wherein flow of oxygen-containing gas into one or more of superior upflow channels of said bioreactor is adjusted independent of fluid flow rate into said one or more superior upflow channels,

51. The improved waste water treatment process of claim 42, wherein flow of oxygen-containing gas into a first superior upflow channel of said bio-reactor is adjusted independent of fluid flow rate into said first superior upflow channel.

52. The improved waste water treatment process of claim 42, wherein recycling or recirculation of degassed fluid from a head tank of said bio-reactor into a superior upflow channel of said bioreactor is adjustably controlled by a system microprocessor-controlled or manual-controlled valve or baffle actuator.

53. The improved waste water treatment process of claim 42, further comprising mechanical mixing and/or bubble generation in a mixing zone by operation of a shear header or bubble distribution mechanism integrated with a gas distribution port of said bioreactor to enhance mixing and/or bubble generation in said mixing zone.

54. The improved waste water treatment process of claim 42, further comprising providing a substantially anaerobic environment in a primary downflow channel and a first superior upflow channel of said bio-reactor.

55. The improved waste water treatment process of claim 42, further comprising providing a substantially anaerobic environment in a primary downflow channel and first superior upflow channel of said bio-reactor, wherein operation of the bio-reactor in this mode provides for a final step of nutrient processing including denitrification of nitrate.

56. The improved waste water treatment process of claim 42, further comprising providing enhanced nitrification processes in a second treatment zone of said bio-reactor defined by a second superior upflow channel and a second head tank interconnected by a recirculation channel.

57. The improved waste water treatment process of claim 42, further comprising providing enhanced nitrification in a second treatment zone of said bio-reactor defined by a second superior upflow channel and a second head tank interconnected by a recirculation channel, said nitrification processes driven at least in part by channeling of unspent gas from said primary upflow channel into said second superior upflow channel.

58. The improved waste water treatment process of claim 57, wherein said unspent gas is high in carbon dioxide which provides a source of inorganic carbon to drive said nitrification processes.

59. An improved process for flotation separation of biomass from a biomass suspension or sludge obtained from a pressurized aerobic bioreactor and subsequent dewatering of the sludge, the improvement comprising the addition of an acidifying agent to the biomass suspension or sludge prior to flotation.

60. The process of claim 59, wherein the bioreactor is a vertical shaft bioreactor.

61. The process of claim 59, wherein the acidifying agent is a mineral acid.

62. The process of claim 61, wherein the mineral acid is sulphuric acid

63. The process of claim 59, wherein the acidifying agent is an acidic coagulant.

64. The process of claim 63, wherein the acidic coagulant is alum

65. The process of claim 63, wherein the acidic coagulant is ferric chloride

66. The process of claim 59, wherein the pH of the biomass suspension or sludge is reduced to a value between 3.0 and 5.5 before flotation separation.

67. An improved waste water treatment process utilizing a long vertical shaft bio-reactor comprising simultaneously diverting a predetermined fraction of oxygen-containing gas rising in a primary upflow channel of said bio-reactor into one or more superior upflow channels, and simultaneously diverting a different fraction of total fluid flow into one or more of said superior upflow channels, wherein non-plugging flow in said primary upflow channel is achieved without the use of orifice plates.

68. The improved waste water treatment process of claim 67, wherein flow velocities in said primary upflow channel can be effectively adjusted to as low as .25 ft./sec.

69. The improved waste water treatment process of claim 67, further comprising recycling of degassed liquid and/or raw influent in a first treatment zone of the bio-reactor to allow deoxygenation without mechanical mixing.

70. The improved waste water treatment process of claim 67, further comprising recycling of degassed liquid and/or raw influent in a first treatment zone of the bio-reactor to allow denitrification without mechanical mixing.

71. The improved waste water treatment process of claim 67, further comprising maintaining an aeration rate between about 0.2-0.5 mg/L DO without changing residence time in said primary upflow channel of the bio-reactor.

72. An improved method for constructing a vertical shaft bioreactor comprising the steps of:

placing a cylindrical reactor housing defining an inner reactor wall into an excavated reactor site;

inserting a modular reactor component having a central conduit surrounded by one or more channel-forming radial partition(s) within said cylindrical

housing, said modular reactor component being deformed during insertion to displace said radial partition(s) away from said inner wall by expanding a diameter of said central conduit in a direction generally perpendicular to said radial partition(s);

relaxing deformation of said modular reactor component to bring said radial partition(s) in proximity to said inner wall.

73. The method for constructing a vertical shaft bioreactor according to claim 72, wherein said central conduit is expanded mechanically by a spreader sized and dimensioned for insertion within the central conduit.

74. The method for constructing a vertical shaft bioreactor according to claim 73, wherein the spreader has paired, opposed and reciprocating spreader parts which can be manually, reciprocatingly repositioned between relaxed and expanded configurations.